SPRAY PATTERNS FROM FAN-TYPE NOZZLES FOR APPLYING PAM TO SOIL SURFACES

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BIOGRAPHICAL SKETCHES

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Dr. Kincaid is an agricultural engineer at the USDA-ARS Northwest Irrigation and Soils Research Laboratory in Kimberly, Idaho. He obtained his B.S. in Agricultural Engineering from Washington State University in 1966, and M.S. and Ph.D. degrees in Agricultural Engineering from Colorado State University in 1970. He has been with ARS since 1970, working primarily in sprinkler irrigation water management.

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Gary Lehrsch

Dr. Lehrsch earned a Bachelor's and Master's degree in Environmental Resource Management from Penn State in the late 70's and Ph.D. in Soil Physics from Mississippi State University in 1985. Since then, he has been employed as an ARS soil scientist studying soil erosion and water management. For the past seven years at Kimberly. Gary has been studying the effects of N-fertilizer placement, irrigation management, and precipitation on overwinter N leaching and two-dimensional nitrate movement during crop growing management effects on soil hydraulic and physical properties, and aggregate stability.

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ABSTRACT

When applied to the soil surface, polyacrylamide (PAM) may stabilize soil surface aggregates, inhibit crust formation and reduce soil erosion during surface or sprinkler irrigation, or rainfall. Thus, PAM maintains high water infiltration rates, and enhances seedling emergence in treated soils. In spray applying PAM, it is desirable to apply stock solution at high concentrations to minimize the total volume of solution applied per unit area. The hypothesis was tested that PAM solutions would alter spray characteristics of nozzles. It was found that the spray pattern from typical fan-type nozzles was altered significantly as the PAM concentration was increased from zero (pure water) to 1200 PPM, where the spray coalesced into a concentrated stream. The pattern began to change significantly at concentrations between 300 and 600 PPM. Higher pressures are recommended for PAM application at 600 PPM or higher. These results should be useful in designing spray equipment to apply PAM and similar materials to soils for erosion control or plant establishment.

INTRODUCTION

Polymers significantly increase drop sizes by modifying the dynamic viscosity of the spray liquid, and thus are used to reduce wind drift of sprays (Holmberg, 1995; Sanderson et al., 1994). Holmberg (1995) cited recommended solution concentrations for drift control, ranging from 50 to 300 PPM (parts per million) for various polyacrylamide products. These materials have also been beneficially applied to soil surfaces to enhance water infiltration and improve seedling emergence, likely by increasing aggregate stability and reducing crusting (Ben-Hur 1994; Hoyle, 1983). Ben-Hur (1994) applied PAM at 20 kg/ha to reduce runoff under sprinkler irrigation. At these high rates, it is desirable to apply a more concentrated solution to reduce the total spray volume per unit area. For soil surface application, a uniform application is desired either for complete coverage or narrow strip application. With concentrated solutions, PAM may influence the spray pattern and flow rate from the nozzle. The objective was to determine how the spray pattern or nozzle flow rate may be modified by the addition of a typical polymer type at various concentrations.

METHODS AND MATERIALS

Flow rates and spray distributions were measured in the laboratory. The PAM used in this study was CYTEC Industries Superfloc 836A obtained as a dry powder (80% ai). This is an anionic polyacrylamide (18% charge density) with a molecular weight of 12–15 Mg/mol. Stock solutions were mixed based on the weight of the dry powder. The PAM solutions were placed in a tank pressurized with regulated air to obtain the desired nozzle pressures. The liquid left the tank and passed through approximately 2 m of 6 mm ID hose before entering the nozzle fitting. The nozzle pressure was measured by using a calibrated pressure gage attached to a piezometer tap immediately upstream from the nozzle. The nozzles used were Teejet nozzles from Spraying Systems Co. These nozzles produce a flat fan spray pattern. The nozzles are marked with a four digit number. The first two digits give the fan spray angle in degrees, and the last two digits denote the nominal flow rate of the nozzle in tenths of gallons per minute (gpm) at a standard pressure of 276 kPa (40 psi).

Nozzle flow rate was measured by using a calibrated volumetric cylinder. Spray distribution was measured with a runoff board divided into small adjacent troughs oriented perpendicular to the spray fan. One half of the pattern was measured, and the patterns are assumed to be symmetrical. The widths of the catch troughs at positions relative to the centerline were: 10 mm between 0–30 mm distance; 20 mm between 30–130 mm; and 30 mm between 130–350 mm. The volume caught in each trough was measured. The distributions were calculated as the percent of the total volume applied per unit distance at a particular distance from the nozzle, and displayed as in the following graphs. Measurements were made at PAM concentrations of 0, 300, 600, 900, and 1200 PPM. Tests were run at 138, 276, and 414 kPa (20, 40, and 60 psi) nozzle pressures, and at nozzle elevations of 50, 100, 200, and 400 mm.

RESULTS

The effect of PAM concentration on nozzle flow rate was analyzed by calculating the ratio of the flow rate at a particular PAM concentration to the flow rate with pure water with the same nozzle and pressure. The results for three nozzle sizes (8004, 8006, and 8010) are shown in Figure 1. It appears that PAM increases the flow slightly (1–3 percent) up to concentrations of about 900 PPM, and then decreases the flow at higher concentrations. The reason for this may be that at low concentrations PAM reduces the friction in flow through the nozzle entrance, but at higher concentrations the viscosity effects increase the friction and reduce the flow. This reduction in flow is associated with a drastic change in the spray pattern, as will be shown.

Spray distribution tests were run with the 8006 nozzle, and a 6506E nozzle for comparison. The "E" denotes the "even spray" nozzle which produces a nearly uniform application rate pattern across the fan width, as opposed to the regular nozzles which produce a triangular shape pattern (see Figures 2–6). The regular nozzles are designed to overlap patterns to produce uniform application at nozzle spacings approximately equal to ½ the total fan width. The even spray nozzles would be more suited to strip application from a single nozzle.

Figure 2 shows typical distributions from an 8006 nozzle with pure water at two pressure levels. The application rate decreases nearly linearly with distance from the nozzle (i.e., triangular pattern), and the measured fan width is slightly greater than the width calculated by the manufacturers specified nozzle fan angle for a particular nozzle elevation. The spray width increases only slightly with increasing pressure within the indicated range. Thus, when using pure water, the optimum spacing for uniform coverage should be about 100–110% of the nozzle elevation.

Figures 3 to 6 show the effect of adding PAM to the water at concentrations of 300, and 600 PPM on the spray patterns of the 8006 and 6506E nozzles. In general, increasing PAM concentration decreases the fan spray width, increasing the application rate near the outer edge while decreasing the rate near the center of the pattern. At 300 PPM, for both nozzles, the width is not altered drastically and even increases slightly for the 6506E nozzle and the effect on the pattern shape is moderate. Thus, at concentrations of 300 PPM or less, the pattern may be considered to be unaltered for practical purposes. At 600 PPM, however, the pattern changes drastically, the effect being more pronounced at lower pressure.

The pressure effect was further explored by running additional tests with the 8006 nozzle at 414 kPa (60 psi) and 600 PPM PAM solutions. These results are shown in Figure 7, in comparison with pure water at 276 kPa (40 psi). As pressure is increased, the pattern width increases and the peak rate de-

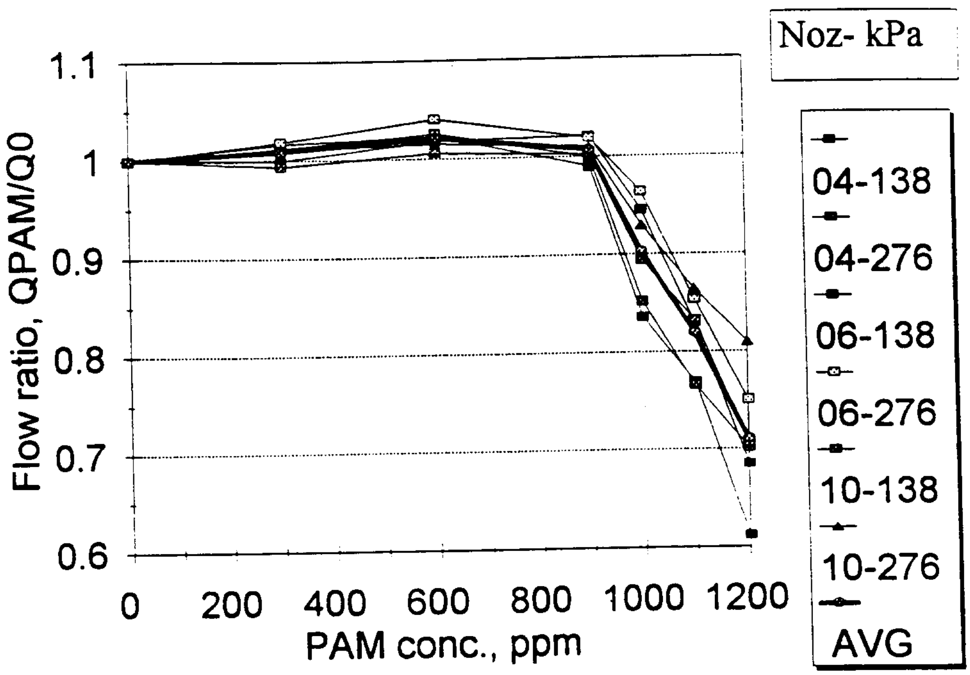

Figure 1. Effect of PAM concentration on flow from 8004, 8006, and 8010 nozzles at pressures between 138 and 276 kPa (20 to 40 psi).

creases. The pattern at 414 kPa (60 psi) with PAM at 600 PPM is nearly the same as the 276 kPa (40 psi) pattern with pure water. Thus, the adverse effect of high concentrations of PAM on pattern shape can be overcome by increasing the nozzle pressure. Attempts to measure the pattern shape at 1200 PPM were not very successful, as the spray tended to coalesce into a concentrated stream and results were very erratic. It is possible that good spray patterns could be obtained at higher pressures. Other types of polymers may have slightly different effects on the spray patterns. We intend to further explore other materials in the near future.

CONCLUSIONS AND RECOMMENDATIONS

1. The standard 80 degree Teejet nozzle at 276 kPa (40 psi) should produce high uniformity at nozzle spacings of 100–110 % of the nozzle elevation.
2. Adding PAM at concentrations up to 300 PPM should not require any changes in spacing or flow rate for uniform application.
3. At the standard pressure of 276 kPa (40 psi) and concentrations of 600 PPM or higher, the pattern changes significantly. To a degree, the pattern can be improved by increasing the nozzle pressure to 414 kPa (60 psi).
4. At concentrations above about 900 PPM the flow rate starts to decrease, and the spray pattern degenerates into an erratic stream.

DISCLAIMER

Trade names and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment of the products mentioned by the USDA Agricultural Research Service.

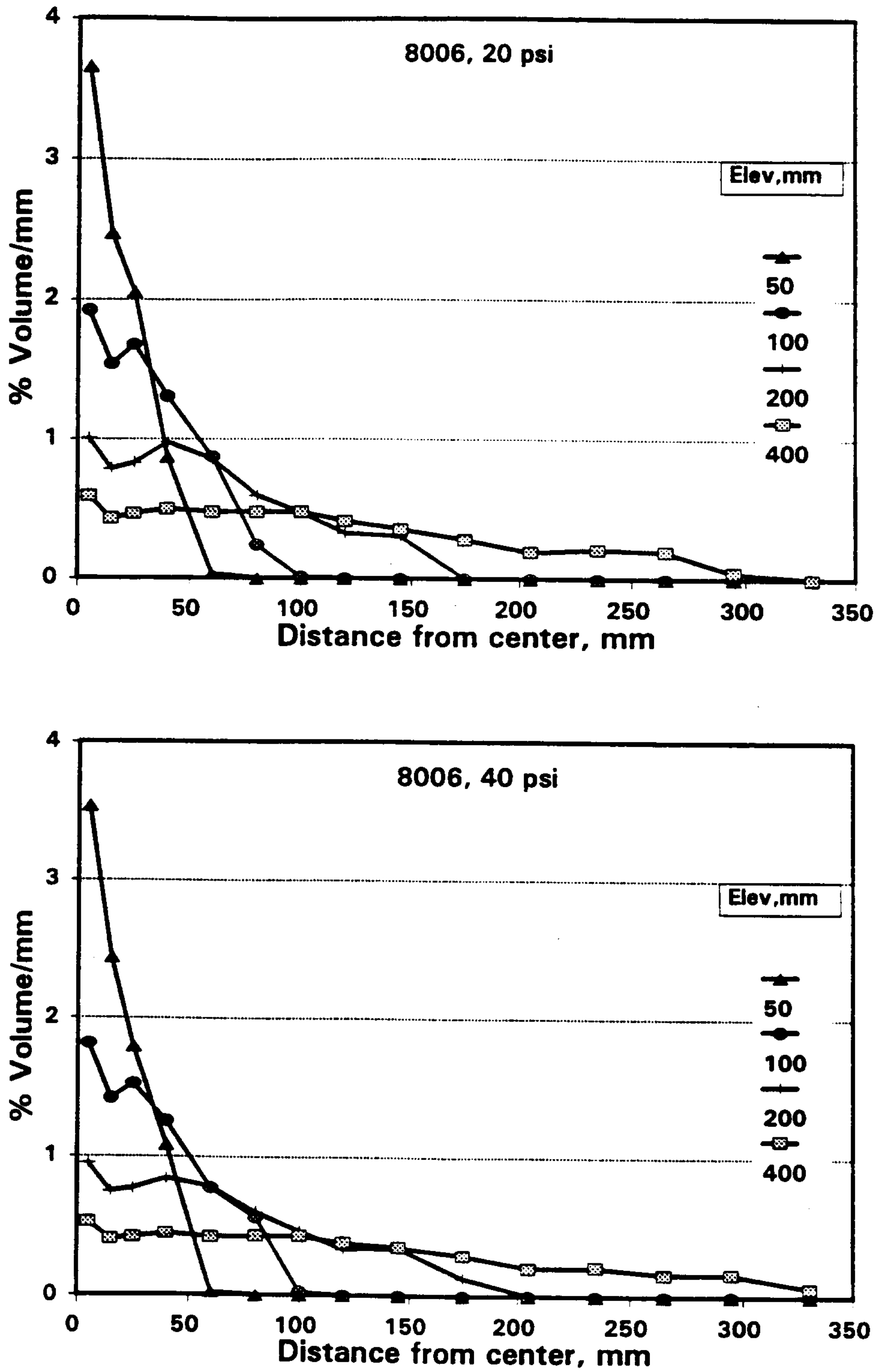

Figure 2. Spray pattern from an 8006 nozzle with pure water.

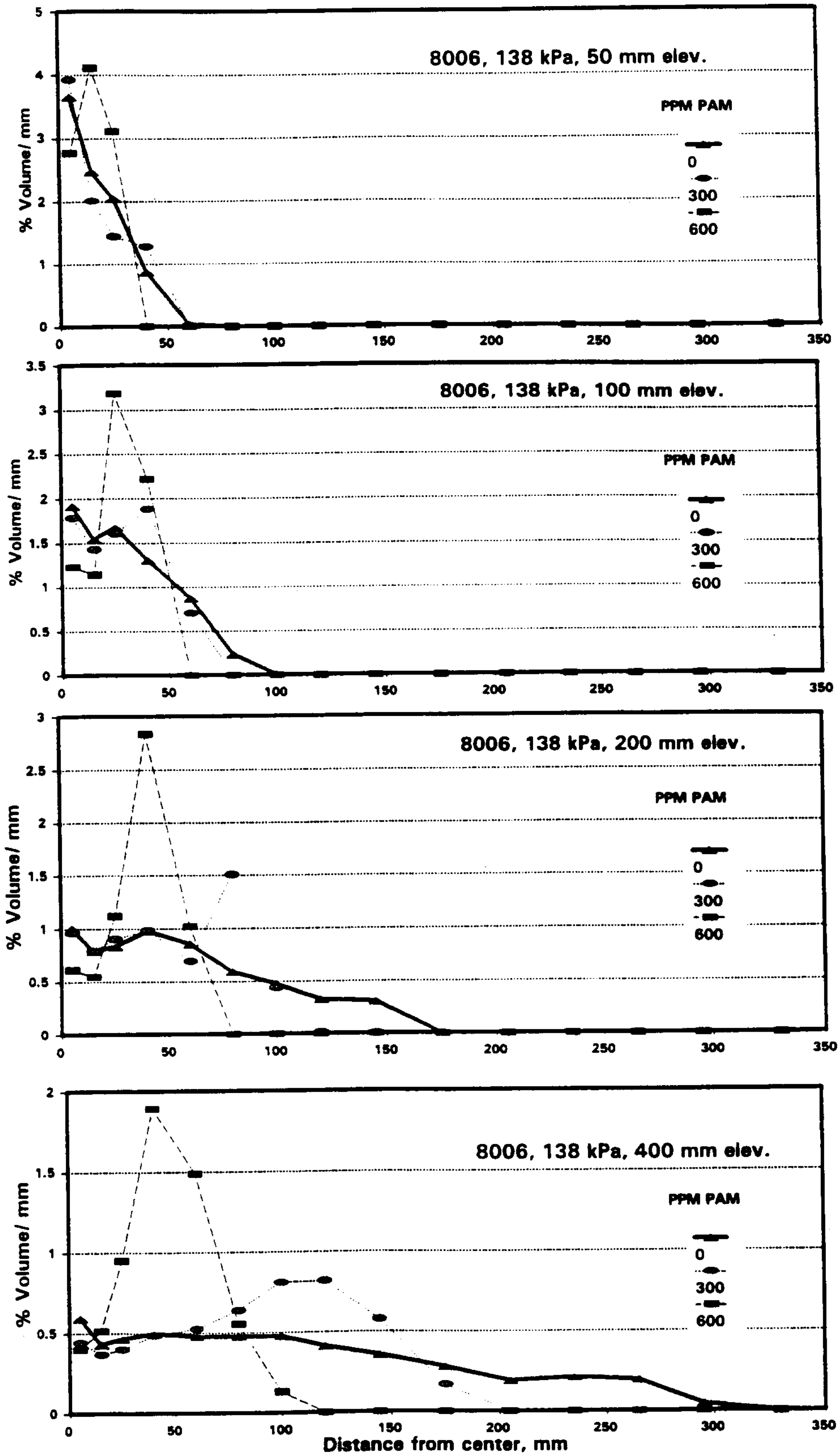

Figure 3. Effect of nozzle elevation and PAM on spray pattern for an 8006 nozzle at 138 kPa (20 psi).

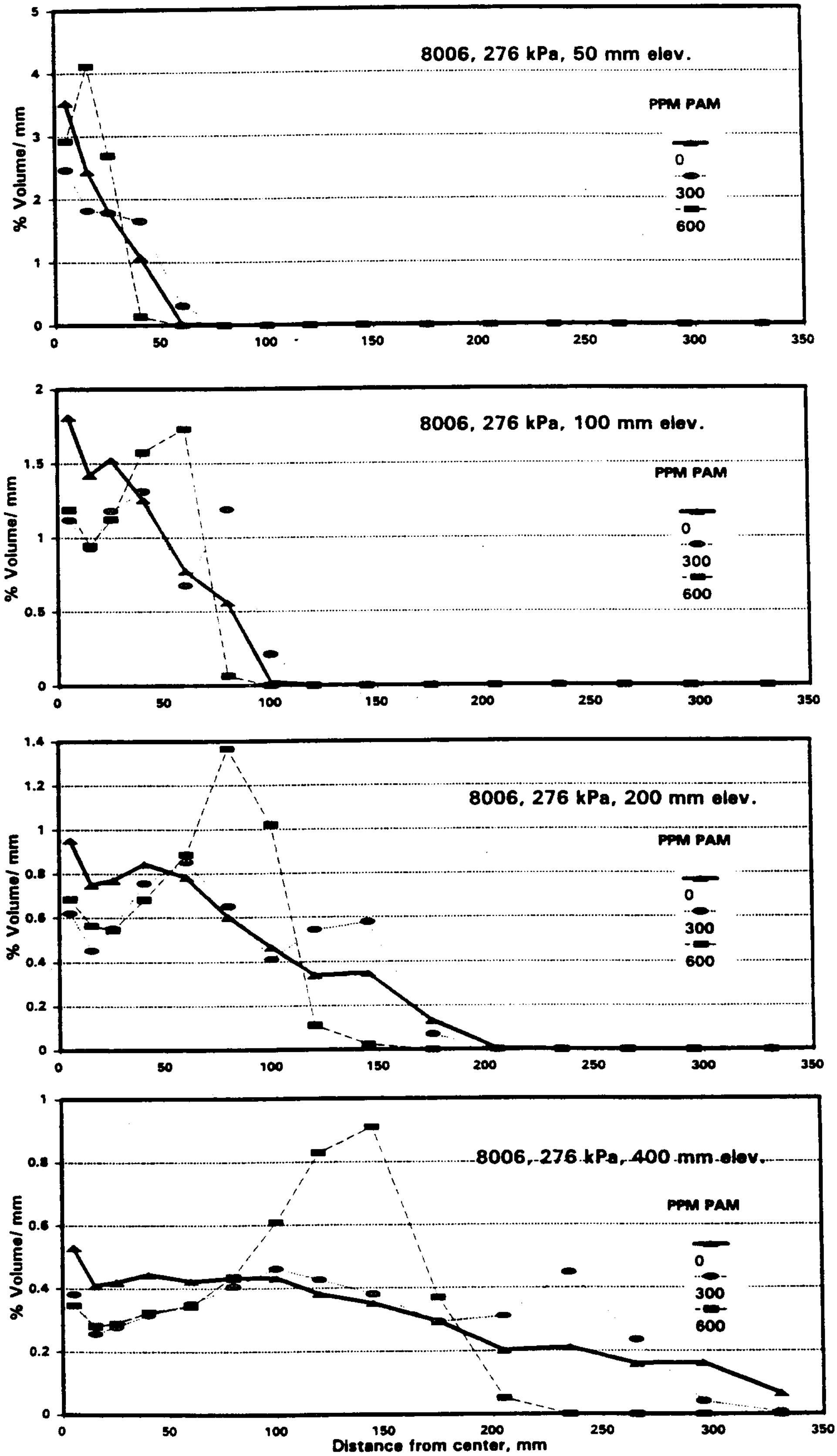

Figure 4. Effect of nozzle elevation and PAM on spray pattern for an 8006 nozzle at 276 kPa (40 psi).

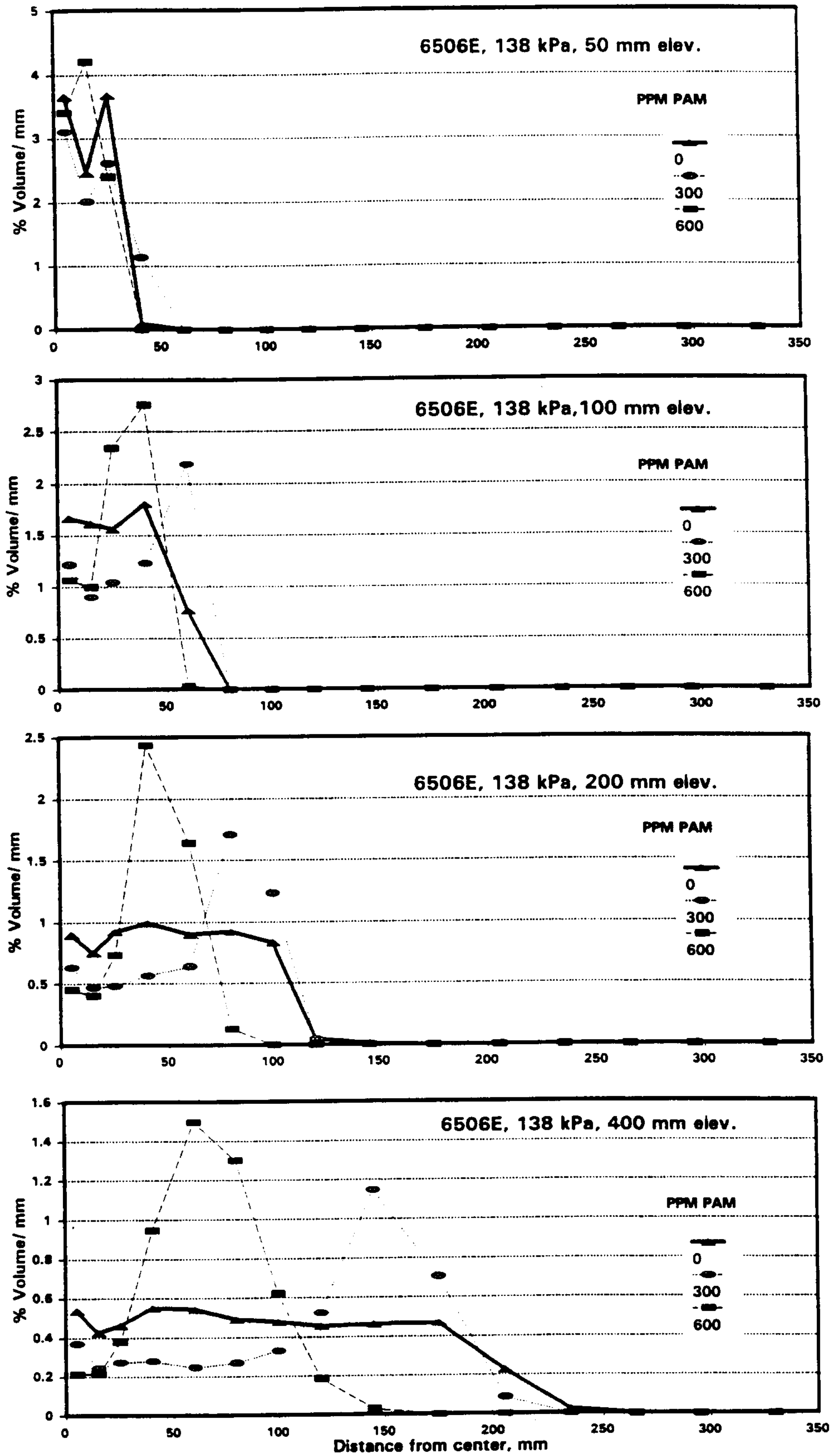

Figure 5. Effect of nozzle elevation and PAM on spray pattern for a 6506E nozzle at 138 kPa (20 psi).

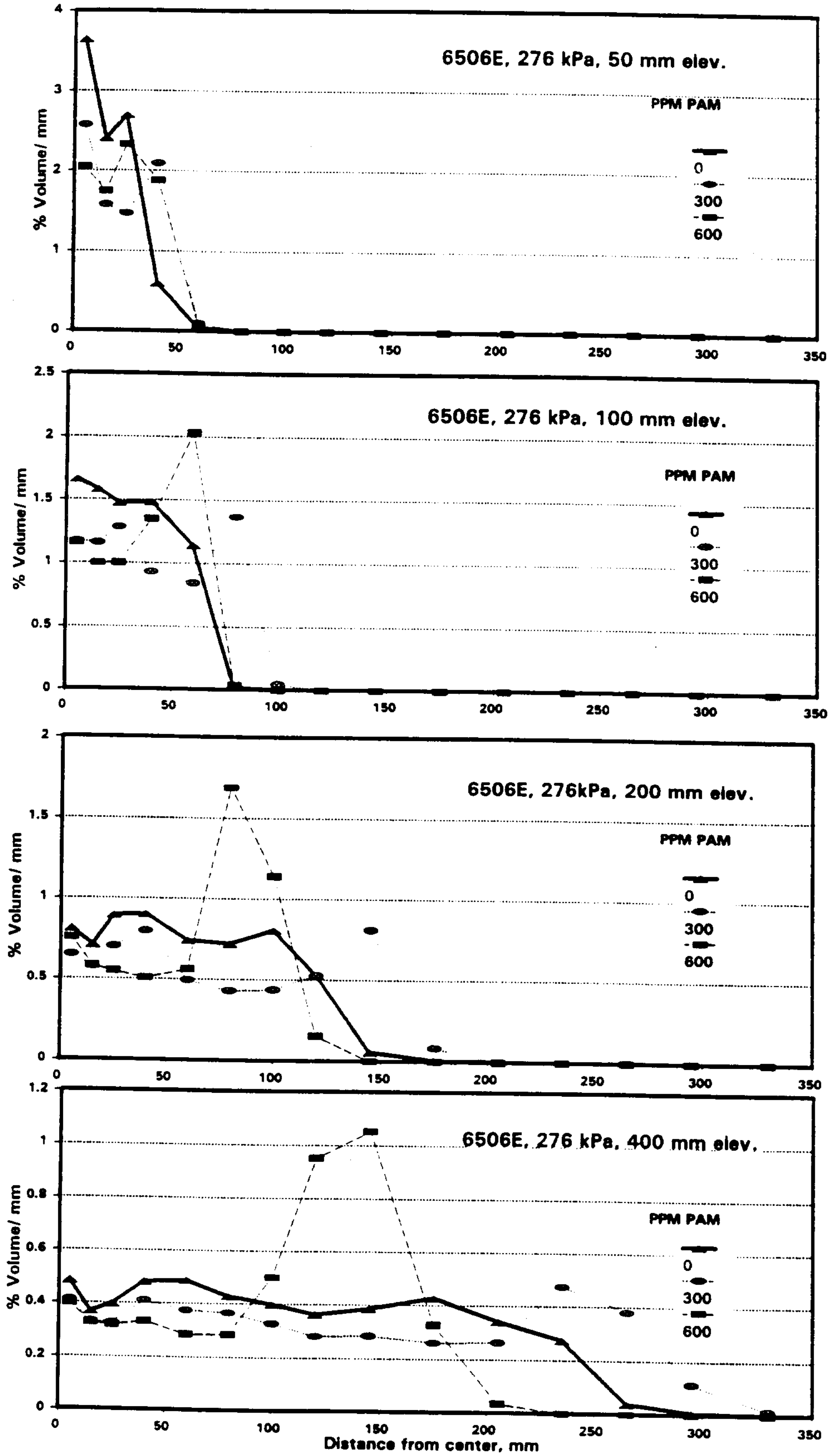

Figure 6. Effect of nozzle elevation and PAM on spray pattern for a 6506E at 276 kPa (40 psi).

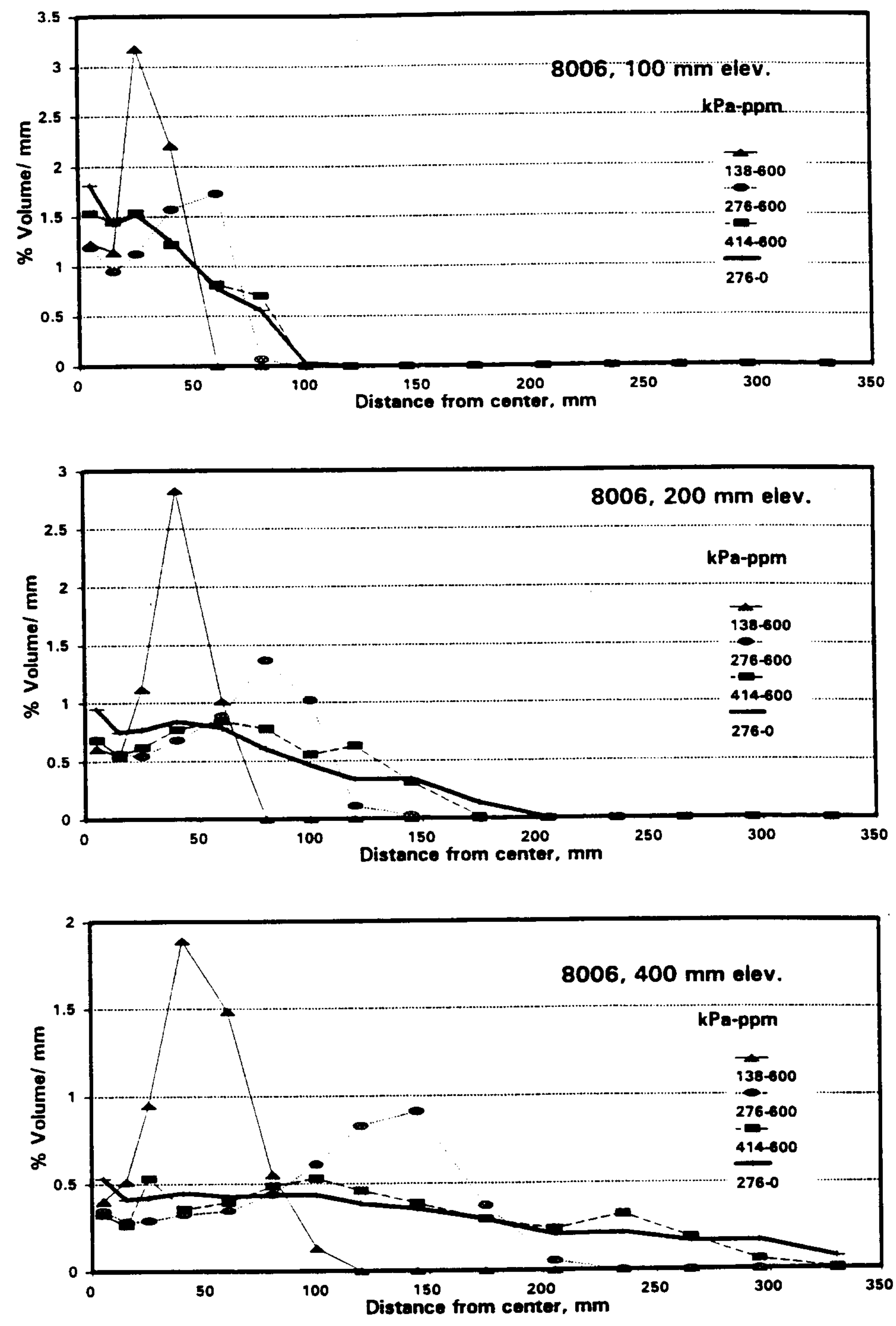

Figure 7. Effect of pressure level on spray pattern from an 8006 nozzle at 600 PPM PAM concentration.

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